Pyrotechnics 55

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FROM THE GROUND UP

Adventures in Homebrew Rocketry

by Chris Tucker

Many years ago, when I was in Junior High, I developed an interest in model rocketry. Unfortunately, it was all but impossible for minors to buy Estes engines at the time. Coupled with the fact that the nearest hobby shop that sold engines was an hour drive away, it looked like my budding career as a rocket scientist was doomed.

Of course, like practically everyone reading PYRO, I didn't let the fact that something seemed impossible stop me.

First stop, the library. I recalled that the Chinese used gunpowder to propel fireworks and spears. This implies that they had some way of making rockets. Hmmm. Not much to go on. Bamboo tube, filled with black powder. Sounds dangerous. Now, look up "Black Powder, how to make". Oh, that looks easy. Too easy. Let's delve deeper into this.

So, a month or so later, I was armed with stacks of photocopies and mail-ordered chemicals. (Pre-1968, ordering all kinds of stuff through the mail was easy, even for Jr. High student. Just use a typewriter and a money order.) Making the gunpowder was messy and time consuming. I restrained my impulse to help the drying process along with artificial heat.

Bamboo was easy to obtain, but the powder kept falling out of the bottom. OK, I need a binder of some kind. After much experi-mentation, I discovered that plain gelatin, mixed with the powder and lightly dampened, caused the powder to form a nice solid. One of my photocopies showed that hollowing out the center of the charge would produce a more consistent thrust. This is getting complicated. OK, stick a pencil into the charge and let the powder set.

First Flight. OK, it's got a nose cone and fins and a launch stand. I have coil of fuse pressing against the inside of the charge to ensure ignition. Light the fuse, run away! Hide behind that BIG tree. WHOOSH! Hey, it works! This is cool!

Evolution In Action. So, the bamboo rockets were fun and all that, but I wanted more. More power, more altitude, more adrenaline. I did some more research and discovered things like nozzles and the Venturi effect. I also discovered a really cheap hand-pumped hydraulic press.

Not having access to machine tools, I decided on the next best thing. Ceramics! Taking an art class that fall got me access to the ceramics supplies and the kiln. Soon, I was churning out dozens of nozzles at a time. The problem was that bamboo is not a uniform product. I needed something that wouldn't change diameter with each new piece. Ah. Copper water pipe! Some careful measurements and a flash of inspiration led me to design new ceramic plugs just a little red hair larger in diameter than the inside diameter of the copper piping. This involved the lost wax process, sandpaper and elbow grease. Heat the end of the pipe with a butane torch, get it nice and hot and slide in the plug. The metal cools and securely hugs the plug. Now, about that hydraulic press. Using another piece of pipe, some dowelling and washers, I rigged up a press that would compress the dampened powder in the pipe around a dowel. Let it dry a few days and then push out the now solid charge. This would slip into the opened end of the rocket tube. Atop the charge, I had a spacer plate with a small hole in it for the chute deploy charge fuse. The charge was a small amount of black powder, firmly packed around the fuse. Another spacer plate and the chute. The spacers were balsa wood, and the support cord for the chute was tied to a lug, soldered to the outside of the rocket. The nose cone was a simple carved piece of balsa as well.

in the Mark One incarnation, guidance fins were soldered to the bottom of the rocket . The Mark Two had a set of

angled fins molded into the ceramic nozzle, and provided a stabilizing spin via deflected exhaust. The Mark Two launch tower was a length of copper tubing that the rocket slipped into from the bottom, much like a bazooka.

A couple of Mark One flights were made at night, using a strip of burning magnesium attached to the rocket to track the flight. These were launched into Narragansett Bay. (With, of course, all due regard for the safety of boaters. Two in the morning was a safe enough time for this sort of thing.)

My remaining Mark Two rockets were eventually lost in trees or in catastrophic launch failures. The last one was fitted with a pointed steel tip from a javelin and launched at a phone book. The resulting hole was impressive, as was the sight of the rocket sticking into the fallen tree that the phone book was resting against.

I stopped homebrew rocketry when a hobby shop opened up in town and it became easier to buy engines. Making these rockets was hard work and I was getting nervous making gun-powder. Mail ordering the fixings for explosives was not a Good Idea in 1968.

So, I played around with the Estes rockets for a while. But the thrill was gone. Building an Estes is nothing compared to making a rocket, including the engines, from the ground up.

[Editor's note: PYRO advises against squeezing black powder in a hydraulic press, attaching javelin heads to you rockets, or doing just about anything else Chris describes. We hate to lose subscribers.]...and while we're on the subject of scary rocket stories...

HENRY'S SCARY STORIES OF SPACEFLIGHT:
The Untold Story of Apollo 13
Henry Spencer

(As you might guess from the title, I hope to do a series of these. They won't all be scary. But there are a lot of interesting stories in the space program that don't get into the mass media...)

So, you say you know what happened to Apollo 13? Well, you're wrong: you don't know *everything* that happened to Apollo 13. (Some of you may not even know the full scoop on the accident en route to the Moon; maybe I'll tell that one in a later installment.) Almost certainly you don't know that Apollo 13 came within a hairsbreadth of being the first and only catastrophic launch failure of a Saturn V. Had this problem not been overshadowed by later events on the same flight, it would have gotten more attention. As it was, even in the best histories you'll barely find mention of it, and the details are very hard to find.

When the Saturn V was first flown, a number of big rockets had already suffered from a problem called "pogo." Imagine a rocket engine in operation. Suppose the pressure in its combustion chamber rises slightly, from some random cause. This increases the back pressure against the pumps feeding fuel in; the fuel inflow slows slightly. The reduced flow of fuel causes chamber pressure to drop, reducing the back pressure, and you can see how this goes. The changes in chamber pressure also affect the engine's thrust, and thus the hydrostatic pressure of the columns of liquid between the tanks and the pumps. There's lots of potential for oscillation here, especially when the frequency of one of these feedback loops happens to match a resonant frequency of the rocket's structure. And the resonant frequencies sweep over wide ranges as the tanks go from full to empty. The result can be an oscillation, at a frequency of perhaps a few Hz, that would just about shake your teeth loose if you were riding on top of the thing. This was dubbed "pogo," after the resemblance to a pogo stick (it's not an acronym).

The first Saturn V (Apollo 4, an unmanned test) didn't have any pogo problems. The second one (Apollo 6, another test) did: a violent 5-Hz oscillation in the middle of the first-stage burn. This one was fixed pretty easily, by adding helium-filled cavities in the LOX lines to act as dampers. (The cavities actually were already there, in the main valves, and all that was needed was to fill them with helium.) NASA was confident enough of this fix to use the very next Saturn V for a manned mission, Apollo 8. There was a minor problem at first-stage ignition, when the engines ingested some of the helium and "burped", but there was no pogo... in the first stage.

Near the end of Apollo 8's second-stage burn, the astronauts felt a bit of pogo. The second stage had five engines, four in a square and the fifth in the center. It turned out that the center engine, and only that engine, was oscillating at 18 Hz. The resulting motion of the whole rocket wasn't strong enough to be a problem, but there was some concern about the local effect on the second-stage structure, and a fix was considered important.

Apollo 9 tried the simplest fix: increasing the LOX tank pressure to try to alter the natural frequency enough to kill the oscillation. (It turns out, by the way, that in a hydrogen-oxygen rocket, problems like this are invariably in the LOX system: liquid hydrogen is so compressible that it makes a good vibration damper all by itself, and rarely gives trouble. That is, it rarely gives *this* sort of trouble...) Unfortunately, the nice simple fix didn't work; if anything, the pogo was stronger.

For Apollo 10, NASA decided to avoid the problem rather

than fix it. Since the pogo occurred quite late in the second-stage burn, the center engine could simply be shut down 75 seconds early, before the pogo started. The remaining engines would burn a bit longer to use up the extra fuel, and the overall performance loss would be small. Apollo 10 did this, and had no pogo in the second stage. However, this time pogo showed up at 20 Hz in the *third* stage. NASA tentatively assumed that this was a fluke and that it would not repeat itself.

On Apollo 11, the astronauts complained about "pogo" in the third stage, but this turned out to be a problem with a vent valve, not true pogo at all. More ominously, the engineers analyzing the flight records found that the second-stage center-engine pogo was back, this time at 16 Hz early in the second-stage burn. People started thinking about a more definitive fix.

On Apollo 12, it became clear that the fix really was needed. There were *four* episodes of center-engine pogo during the second-stage burn. The one bit of good news was that there were indications that the oscillation was self-limiting, and was about as strong as it was ever going to get. A pogo suppressor for the center engine was designed and tested.

For Apollo 13, a decision had to be made. The pogo suppressor was ready to fly... but Apollo 13's Saturn V had already been stacked at the Cape. The suppressor was easy to install during manufacturing, but retrofitting into an already-stacked booster would be difficult. Ultimately, NASA decided that it was better to leave Apollo 13's second stage alone; after all, the oscillation appeared to be self-limiting...

At that point, nobody really appreciated just what was happening in the center engine's LOX pump. High-speed pumps typically have areas of quite low pressure on the back sides of their blades. When the pressure goes below the vapor pressure of the fluid, the pump can "cavitate," with a vapor-filled cavity forming in the fluid in the low-pressure region. In particular, it's easy for a pump to cavitate when its input pressure goes below the design value, and most types of pogo involve oscillations in pump input pressure. Everybody knew that cavitation could reduce the efficiency of the pump. What nobody understood, then, was that a cavitating pump can be an enormously powerful amplifier for pressure disturbances in its inlet.

When Apollo 13 flew, at first its second-stage burn looked like exactly what was expected: a repeat of Apollo 12's. The first and second episodes of center-engine pogo were very similar to the previous flight's. The third episode started out the same way... and then the center engine's LOX pump cavitated.

The chamber pressure in the center engine had been oscillating by about 10 psi, peak to peak. In three seconds the oscillation was 500 psi... in an engine whose operating pressure was only 780 psi! Two tons of engine, solidly bolted to a massive thrust frame, was bouncing up and down at 68 Gs, flexing the frame three inches at 16 Hz. It was a toss-up whether the engine would tear itself off its mounts or break the thrust frame first; either event would probably have destroyed the entire second stage.

This time, everyone was lucky. The on-board computer, extremely slow and stupid by modern standards, wasn't smart enough to watch for oscillations. However, it was watching for unusually-low *average* chamber pressure, which would indicate any number of engine malfunctions justifying a shutdown. The center engine's average performance was generally deteriorating, and three seconds into the runaway oscillation, its average chamber pressure got low enough to trip its "low chamber pressure" sensor. The computer noticed, and shut it down, in the nick of time.

In the better histories of Apollo, you'll see some mention of the unexpected early engine shutdown. The remaining four engines burned longer to compensate, and the third stage also had to work a bit harder, but the margins were large enough that a full lunar mission was still possible. Except that things later went very wrong aboard the Apollo spacecraft, but that's another story, and a much better-known one.

The pogo supressor was installed on all subsequent Saturn Vs, and the problem did not recur. There was a little bit of 10.5-Hz oscillation right at the end of second-stage burn on some flights, and everybody was still nervous about possible third-stage pogo (although in fact Apollo 10 was the only time it happened), but there weren't any serious problems. And the shuttle was designed with a pogo suppressor from the start, and has never had a pogo problem.

Quarks

•Barry Gehm, one of our Mis-managing Editors, is now a Research Assistant Professor at Northwestern University Medical School. Letters to the editor that formerly began "Dear Idiot" should now begin "Dear Prof. Idiot."

•Congratulations to Amy Proni, printer and raygun technician, who graduated this spring from Western Michigan University, with a nearly perfect GPA. Obviously the lead type and solder haven't done Amy's brain any harm.

•Dawn Kuczwara has written and starred in an Internet training video. If you think hypertext markup is how much profit Bill Gates makes on software, run out to Borders or Barnes & Noble and get "INSERT TITLE

HERE". Don't wait for the Internet Fairy to leave it under your pillow. ... *QUARKScontinurd on page 9.*

LIGHTNING ON DEMAND?

A while ago a few GTers on our Internet mailing list began to kick around a peculiar idea of Todd Johnson's. We'd like to share this conversation with you. It's been edited and rearranged a bit to keep topics coherent.

Moshe Yudkowsky: If you would be so kind — please tell us who haven't been following more about the Fist of God project. I know about the electric field meter...

Todd Johnson: OK, briefly the "Fist O' God" is the name given to an amateur attempt to recreate NASA's Rocket Triggered Lightning experiments. They have a little facility in a charming swamp called "Mosquito Lagoon" where thay launch small rockets at thunderclouds. The rockets have spools of fine wire around their fins which pay out as the rocket ascends, forming a conducting path for whatever megacoulombs lie waiting in the cloud. The result is a lightning stroke down the wire (or where the wire used to be). There was an episode of *Nova* which showed these experiments, as well as a couple of magazine articles as I recall. The problem with showing this on TV was that it looks too easy; some nut is liable to try it :-). The rockets required are easily within the means, both financial and legal, of most model rocket builders.

Curiously, I've never heard of any private individuals trying this. (Perhaps none survived to report the attempt!)

Daniel Butler-Ehle: Gee, you make it sound like it's sophisticated or something. In the June?July?August? (probably the latter) issue of *Nat'l Geographic,* the cover story was lightning. In it were some pictures and description of Joe "Ihava" Grant's FoG experiment. It looked like they were using modified available-at-Toys"R"We D-engine rockets (only with bigger engines). Could someone explain why the coil of wire unwinds from the rocket instead of from the ground? It seems like deadweight. The "fancy" pneumatic ignition system consisted primarily of someone blowing into a tube. I think pulling a piece of fishing line or pitching rocks at it would work as well. Or maybe hitting the trigger with a .22 slug. I meant to bring the article out to Berserker, but I kept forgetting. It also had some of the neat *Nat'l Geographic* graphics explaining the latest theories on exactly what lightning is. "Um...it's electricity" (Yeah, thanks, Benjamin).

Todd Johnson: Sophisticated?? My point was that they get away with just blowing into a hose to trigger it.

The rocket pictured in *National Geographic* is called a Mustang and is a fairly popular mid-size model rocket. I

imagine that it's fairly unlikely we'd recover the thing , given the concussion of the discharge and the ferocious updrafts present in the cloud, so the experiment would involve a degree of financial sacrifice. (those models aren't free by any means.) Or, someone couold design and scratch-build a rocket specifically for the task. Cheap materials, design the spool into the fins, etc. The only excuse I can imagine for lifting the whole spool is that any given section of wire only spends a fraction of a second in contact with the engine exhaust that way. A spool on the ground would need a long leader on the end of the wire that was impervious to being torched. That might be the way to go, if a suitable leader material can be found.

:*Kevin Nickerson::*

It seems like having the spool on the rocket would put less strain on the wire. If the spool is on the rocket, the deployed wire is stationary. If you leave the spool on the ground, the deployed wire has to move. The more wire deployed, the more air resistance you need to overcome to drag it and the more likely it will break.

Todd Johnson: I think you've hit the nail on the head with this one. Indeed the only strain on the wire would be from the force required to unspool it, not from its own weight or air drag. Looks like the Spool-on-the-rocket design is the winner.

We should still think about methods for generating ionized exhaust paths someday.

Todd Johnson: Even if I never build the doppler velocimeter, I HAVE been making some progress in the F.O.G. project. I built an electric field sensor that can measure the charge accumulated on overhead clouds, non-contact. Of course if you're measuring something that's at 100MV you'd darn well better be non-contact! I've used it to look at a few storms now, one of which I

videotaped, and it does a pretty good job of indicating iminent lightning. The voltage builds over as much as a minute, then sits at a high level for many seconds before discharging. This seems to give a nice window of opportunity for launching a rocket-towed wire. Polarity can also be determined, so you'll know if you're looking at the underside of a local thundercloud (negative polarity) or just seeing the field shine down from the upper levels of a cell farther away (positive polarity).

Now we just need a vehicle designed to carry a conical spool of magnet wire, and a nonconducting ignition trigger system (the big boys use pneumatic switches and a plastic hose. I thought they'd at least use fiber!). Oh yes, one more thing... we'll need Someone Else's House.

Dermot Dobson: Someone else's continent looks a pretty good idea from here!

Todd, how about a rocket engine that leaves either a trail of *very* fine metal particles in its wake or a combustion product that supports an ionization trail?

Todd Johnson: That was considered, but I'm concerned that the rather capricious winds accompanying the arrival of interesting weather fronts might tear the trail up before the rocket gets high enough. Probably worth some experiments, though!

Dave Ihnat: I'd think that the spools of wire from wire-guided torpedos would be perfect for this. Probably available *somewhere* as surplus; I'll check American Science Center, but don't recall seeing it there (although I could kick myself for passing on the Norden bombsight a few years ago...)

You'd probably have to rewrap the wire onto a lighter/smaller spool...

Doug Humphrey: You really need the wire from an antitank missle, not from a torpedo. Torpedo wire is pretty heavy stuff, since it has a torpedo o tow it around. Antitank missles are much closer to the model rocket application, where the wire will have to be very light weight, and will have to uncoil very easily or else it will provide serious drag, and the uncoiling will cause slight directional changes (the lighter the vehicle, the less slight they might be).

Dave Ihnat: Agreed; I was thinking, however, of length. I'm not sure, but I don't think the AT missiles is over 1 mile, if that long; torpedoes, I believe, can be guided "in excess of 3 miles." Splicing is possible, I suppose, although I'd hate to think what happens if the splice snags something...

Todd Johnson: As to what wire to use, I don't know if NASA uses copper or, say, steel wire, but I believe copper should be OK if the spool can pay it out freely enough that it doesn't get snapped from strain. A conical spool like the aforementioned TOW missile, or like Cap'n Al's Sonobuoy should work fine I would think. We'd be better off building it from scratch though, so it can be made lightweight and fit the rocket. One question concerned lifting just one end of the wire and leaving the spool on the ground, so the rocket isn't carrying all the wire at liftoff. One would have to have a few feet of steel leader on the rocket so the exhaust didn't burn through the copper though.

Doug Humphrey: I think that magnet wire can be had in the right lengths, but the stress issues are still there... I bet there is a report *somewhere* that gives us all the data that we need! Might be classified though. Find out who builds these things (for the real weapons systems) and ask them, or better yet get the NASA people to tell you what they used.....

Todd Johnson: The real problem with doing this for a Berserker somewhere is that you have to wait for the weather to cooperate. I suppose we could bring the equipment up with us to guarantee fair weather every year. Practically speaking, if this is really going to happen it should be done in a location close to the home of whoever has the parts so they can be deployed in a couple hours if the forecast looks hopeful. (When I say "close", I mean within an hour's drive, not say, in the driveway!) This doesn't necessarily preclude using Wicker's Farm (that's Kathy's job :-)), but we couldn't count on being able to do it With All Our Friends Watching. Let's just say that if someone does try this, you'd better videotape it from six different angles, otherwise if you did survive the experiment you wouldn't survive the wrath of your friends who would like to have seen it.

Bill de Beaubien: Actually, this is easy to deal with. All you have to do is come up with more nifty things to do that require fair weather than foul; that should pretty much guarantee lousy weather for the duration...

Dermot Dobson: Todd, how high (ie how long a wire) do you think the rocket needs to go to attract a lightning strike.

Todd Johnson: On the question of wire length, I think that maybe 3000-5000 feet would be plenty. You shouldn't have to short out the whole cloud; if you launch when conditions are right the voltage up there is so high that all it needs is a suggestion of where to go. Approaching the cloud base should be more than enough of a hint to get things going, so you could even get away with say 2000 feet. Piece of cake.

Dermot Dobson: You gave me an idea that combines both your and my rocket performance monitor. If we fit a Gunn 10GHz transmitter to the rocket and a similar one with a

reciprocal mixer and detector (ie old mwave burglar alarm) on the ground, the output from the Schottky diode should give us the doppler info that we need.

I take the point about frequency stability, but once the Gunn has warmed up (10 mins) they usually stay put within 10Khz, also the drift is very slow (I hope) compared to the Doppler-induced changes we should be expecting.

Who's gonna calculate the resultant frequency range that the monitoring system must support to cover a rocket going from zero to mach 2 9 say) in 3 seconds with a 10GHz carrier.? Of course if we were real clever, we could put colour video on the same carrier as well.

This technique should be easier to implement reliably, bearing in mind the distances involved, than a purely passive system. I don't want to think about the path loss involved of using a passive 2" reflector at 2 miles range. I have a few Gunn systems that work well over 5 miles with colour video, just using a 1.5" by 2.2" horn antenna.

Such an antenna has a half-power beamwidth of about 40 degrees. Be useless during the recovery phase while on the ground though.

I've just been given a camera we can use to replace the one that Chris lost. It is faulty but the manufacturers do a flat rate repair. I've used this model before, and digitised some very good 576 by 768 pixel images with it. Monochrome only, but I'm still looking for a colour one.

Todd Johnson: And regarding the Doppler rocket flight measurements: Back of the envelope says that the difference signal would still be below 100 KHz, a piece of cake. (Unless I'm completely off base...) I like the idea of a transmitter on the rocket as long as we can guarantee that the acceleration-induced stress won't distort the cavity enough to shift the frequency and mess up the velocity data. Maybe it's not a problem...

Dermot Dobson: On the Fist of God project, why not use a totally non-contact way like radio, to launch? I wouldn't want to hold the end of *anything* that a lightning bolt was exploring the other end of.

Todd Johnson: The point about using a coded IR or RF trigger is well taken, but it had better be well-coded since there's a lot of RF and optical noise going on while this thing is being set up.

The pneumatic trigger seems like a real kluge, but it's cheap and nonconductive. If you want to yank on a fishline, how close do you intend to be to the launch platform? Wouldn't want half a mile of line to get caught in the grass somewhere. I like Dermot's assertion that an entirely hands-off approach would be preferable. If we've got the resources to build a coded rf trigger, by all means let's use it. If this experiment actually happens, I don't want to settle for "Oh, it's safe enough." There's some serious energy flying around, like 100K joules/meter, so I'd like to be as careful as possible.

Dermot Dobson: On a final destructive note, when I was working on a high power laser project for skin cancer and tattoo removal, we could crank up the power of the laser so high that we got a line of ionization (with little focus/defocus blobs along it) right down the length of the lab. Anyone got a disposable laser we can try and point at a thunderstorm?? (If it works you don't get a second shot!!)

Moshe Yudkowsky: How about a disposable mirror? The bolt hits the mirror, goes to ground, and ignores (one hopes) the ionization path's puny conductivity...

Todd Johnson: ...And in fact the Japanese are trying just that! Their power utilities are developing a laser trigger system to steer lighning away from power transmission towers. I saw a photo of a test where a large pulsed CO2 laser steered a high voltage discharge several meters to a ground electrode. It takes a bit of power, though, like 10^9 watts/sq.cm. It's not apparent from the article how they intend to guarantee the lightning won't go up the laser's nose and blow it up, but they do plan to use mirrors closer to ground than the laser (not much of a guarantee if you ask me).

Dermot Dobson: Yup, a grounded metal mirror should do, all we need now is the laser and someone else's country!

Todd Johnson: Are there any ideas of what we should do with this if it works? Imagine you know where and when lightning will strike. How do you use this knowledge? I'll throw out some "seed" ideas:

- Connect the wire to a rail gun.

- Connect it to a "charged" cold-fusion cell (what the heck!)

- Launch from a sand pile and make your own fulgurites (look it up yourself)

- Connect the wire to a barrel of ball bearings and let the lightning spot-weld them into an interesting sculpture.

- Anchor the wire to the middle of the road, and when the Roadrunner comes around the corner... Scratch that, it's definetely asking for trouble.

Dermot Dobson: The forces involved are presumably sufficient to do a bit of explosive deformation—lightning forged GT belt buckles [all you got to do is find them

afterwards]

Todd Johnson: I like it!!

Dermot Dobson: How about using the incoming bolt to pump a single shot laser at the next likely canditate cloud? Any simple technologies around to be lightning pumped? [doesn't have to be too efficient, we've got a *lot* of power here.] Todd, have you thought about building a BIG capacitor a la Riverworld?

Although I've seen the term bandied around a lot - I don't know what's *in* a free electron laser.

Todd Johnson: ...Well, free electrons. Not to be a smartass, but a normal laser uses the electron energy level transitions in atoms to make photons, right? Well the free electron laser dispenses with the pesky nucleus and the discrete energy levels. You take an electron beam of I believe many MeV and several *amps* (i.e. a color TV won't work) and run it into an array of magnets that wiggle the beam back and forth in tight little hairpin turns. Put some cavity mirrors on either end of the magnet and the (synchrotron radiated) photons that fly off will get phaselocked to each other. What's nice is that the photon energy is *adjustable* by changing the E-beam energy. This is basically what goes on, but there are certainly more knowledgeable persons on the subject than me.

Dermot Dobson: What else? I suspect that normally impossible chemical reactions can be made to go, you can probably achieve unusual metallurgy results as well.

I am attracted to the idea of the "Art from Technology" approach in the fulgurite and ball bearing sculpture ideas though.

We've had a rather lightning-free year here, maybe the E.C. is stealing our thunderstorms for stockpiling.

Doug Humphrey: I have always wanted to do this, but put a 50-gallon drum of popping corn on the ground around the grounding spike.

Dave Ihnat: Now, that's Reel Genius...

Todd Johnson: Excellent! We'd all have a nutritious snack afterward. This reminds me of a project proposal we came up with maybe 12 years ago: A laser popcorn popper which drops one kernel at a time into a reaction chamber where it is rapidly heated by converging beams from an array of YAG lasers *a la* inertial confinement fusion machines. It was of course called Shiva Redenbacher...

Barry Gehm: You left out one of the classics:

• Connect the wire to a bunch of patched-together cadaver parts.

Todd Johnson: Right. I'll bring the rocket, you can bring the, uh, target.

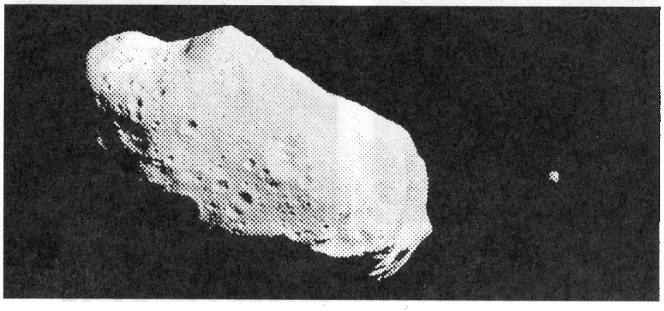
Todd Johnson: We could construct a layered target for the lightning strike to give several ideas a try: Popcorn on the top layer, then sand, ball bearings, maybe plastic beads, and finally something from Barry in a shallow grave on the bottom. Oh, and let's not forget Dermot's belt buckle (sans Dermot, one would hope).

FOUND ORBITING ASTEROID IDA

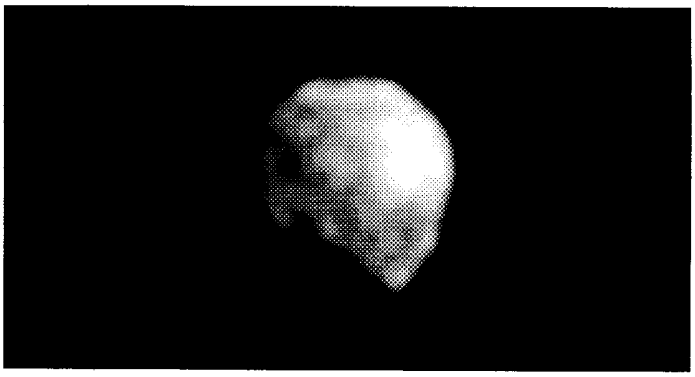
Bill Higgins

As everybody knows, I'm very interested in the progress of interplanetary spacecraft. So on March 23rd 1994, when NASA announced that something strange had been discovered in the data streaming down from the Galileo spacecraft, I hastened to grab copies of the pictures from the Net and stick them into my new Macintosh.

Galileo is on a journey from Earth to Jupiter lasting many years. She was launched in 1989 and will, *Deo volente*, enter Jovian orbit on 7 December 1995. Her spiraling path



through the Solar System has taken her past Venus, Earth, Moon, and the asteroid Gaspra. In August of 1993, Galileo sailed past a main-belt asteroid known as Ida, snapped a lot of pictures, and stashed them on its tape recorder. A busted antenna limits the downlink data rate to only 10 bits per second, or sometimes 40 bps when the Earth is a little closer to the spacecraft. So many of the images of Ida didn't arrive on the ground until the spring of '94.



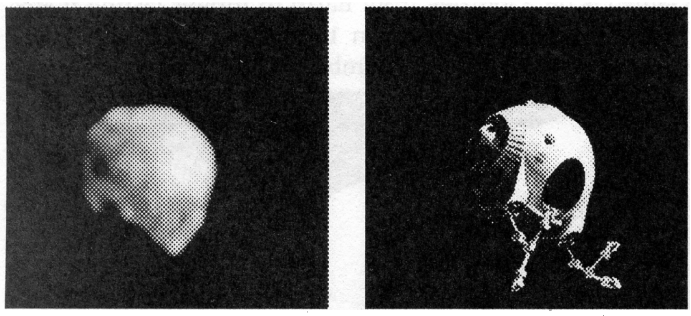
The astonishing thing that appeared in these pictures was a little white dot near Ida (Figure 1). Scientists said that it was moving around Ida: An asteroid orbiting an asteroid! First time anybody had solid evidence of an asteroidal satellite. Later, they named it Dactyl. The Dactyli were a gang of creatures who hung out with the nymph Ida on Mount Ida in Greek myth.

Well, I stared and I squinted at the blurry round dot. I could see indistinct patterns of shadow. After a while it began to look a little familiar. What was it?

I went to my library, found a picture of the familiar object, slapped it on a scanner, and made a few improvements. Cropping, rotating, scaling, stretching, and matching background shades, I soon had an illustration that wordlessly explained my theory perfectly. (See Figure 3.)

Proof, perhaps, that it is dangerous to put digital image processing in the hands of the masses...

Mysterious Object Found Orbiting Asteroid Ida
(Where have we seen this before?)



FOUR SCORE AND SEVEN DAYS AGO

Bonnie Jones

For those of you who are thinking about starting your own country, or looking for a small inexperienced one to invade, our Cartography Correspondent reports on the planet's newest nation. A Worldcon bid is rumored to be in the works...

Palau, the final U.N. Trust Territory of the Pacific, which had been administered by the United States since the close of World War II, gained its independence at the end of September. It becomes the world's 192nd independent country.

The independence of Palau at this time comes as a surprise. Between eight and ten referenda had been held to achieve the required approval by 75% of the electorate for the proposed constitution. Until Nov. 9, 1993, all had failed with the support ranging between 55% and 75%. The failures were due principally to opposition to the Compact of Free Association with the United States that the new constitution would establish. The Compact would permit U.S. ships and aircraft to enter Palauan territory without revealing whether or not they carried nuclear weapons.

The most recent referendum passed only after the required margin of approval was lowered by the Palauan legislature, which was alleged in two lawsuits not to have the authority to do so. The Palau Islands are a part of the Caroline group in Micronesia. The chain of islands extends about 100 miles north to south and 20 miles east to west and are located about 500 miles east of the Philippines. The northern islands are of volcanic origin and the southern ones are coral. About two-thirds of the 15,000 people live in the capital city, Koror.

The Palau islands belonged to Germany before World War I. The Allies gave them to Japan after the war. After World War II ended, the Japanese settlers were sent back to Japan. Since 1947, the United States had controlled the Palau Islands under a United Nations trusteeship. Palau is the last of the Trust Territories of the Pacific to become independent. The others were the Republic of the Marshall Islands, Federated States of Micronesia, and the Commonwealth of the Northern Mariana Islands.

JURASSIC BLUNDERS?

by Mary Lynn Skirvin Johnson

With a thundering roar and a gnashing of slavering serrated jaws JURASSIC PARK has at last been released to video tape. This has given some of us the golden opportunity to gleefully take this mega-blockbuster apart gobbet by gobbet and expose some of the glaring plot and editing errors cleverly concealed beneath the glitzy, if not totally overwhelming special effects.

Unlike the gripping read that the original Michael Chrichton novel was, the movie trips and stumbles all over its own plot feet in an effort to concentrate on the incredible achievements of the ILM special effects team. Let me state from the outset that I LOVED the dinosaur animation. So much so that a scene early in the film showing a herd of dinosaurs drinking at the edge of a lake where brachiosaurs are wading, all in the glittering sunlight of morning actually moved me to tears. It was a beautiful piece of work.

BUT, the plot was another matter entirely. Let's start with the scene in which Grant and Sattler get out of the tour vehicles and encounter a sick triceratops. (In the book it was a stegosaurus.) Both in the book and the movie, Sattler notices that the dinosaur has lesions on it's lips and mouth. She also notices its dilated eyes and labored breathing. Things start to falter badly when she does the almost-too-gratuitous scene of her with her arms up to the

elbows in dino-droppings. The kids might've liked that part but I thought it was just lame. From the beginning of the sequence we follow her as she tries to discover the cause for the creature being ill and just when it looks like she might tell us the answer, she mumbles something about getting a ride back with someone else and the whole plot thread just dribbles off there. No answers, no resolutions or revelations. Nothing. Conversely, in the book, she discovers that the animal had been injesting poisonous berries along with it's periodic load of stones it needed for gizzard stones. Todd and I feel that that part was probably filmed but for some reason, ended up on the cutting room floor.

The next gaff is a small but significant one. Both the movie and the book claim that the dinosaurs could all be killed off in short order because they were genetically unable to obtain the lysine they needed to survive. However, lysine would be available in abundant quantities to a predator. Mammals are chock full of the stuff, (remeber the cow that was fed to the raptors?). Even the herbivores could get by since the substance can be found in some tropical and sub-tropical plants.

My last gripe is a major one. How the editors and the continuity people let this one get by I don't know.

Early in the film the two tour vehicles stop next to the Tyrannosaur paddock and we get several establishing shots that show us that the pen is on one side of the road and that there is an open field on the other. To lure the beast into showing itself, a goat is introduced into the pen by way of a small lift. The tyrannosaur, however, fails to appear.

Later, when the tour is trying to wend its way back to the visitor's center during the tropical storm, both vehicles once again stop in the same spot next to the tyrannosaur pen. The fact that it is the same spot is verified by the presence of the goat, who has not yet been eaten. Also, this time, the electric fence is now on the other side of the vehicles.

When the tyrannosaur finally appears, it is right up against the fence and is busily gobbling the goat. It then tears its way through the deactivated fence and proceeds to demolish the lead car containing the two kids. At one point, Malcomb distracts the beast and it destroys a restroom-building containing an accountant. Where the heck did that out building come from? I sure didn't see it in the first driveby shots of this location, despite the crane/long shots. Then, in a fit of pique, the tyrannosaur pushes the demolished car back through the hole it made in the fence and the car plunges down a 200 foot drop that wasn't there just a little while ago! It couldn't just be a moat since there's a huge tree down there. But what happened to the dirt we saw on that side of the fence in the crane shots? The dirt the tyrannosaur HAD to be standing on before eating the goat. The dirt and undergrowth that surrounded the platform the goat materialized on? Poof. Gone. All at the whim of an editor that thought we wouldn't notice.

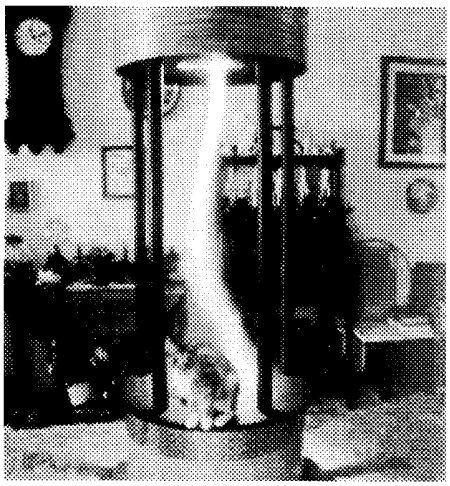
I saw JURASSIC PARK at the theater, and I remember telling Todd afterward that that was as close to a real dinosaur as I'd ever want to get. I even clung to him during the tyrannosaur chase scenes. Utterly wonderful. But if you try to make any sense of the plot, don't bother. It just does not do the book justice.

...QUARKS continued from page 4.

•The Skeffingtones have just completed their triumphant tour of Minnesota. Andy Anda, Bill Higgins and Kelly Matthews wowed a sellout crowd at Minicon with a medley of old favorites and some of Kelley's bluegrass compositions.

•Letters and submissions to PYRO can now be sent by fax. The 24-hour fax number is (708)-897-8448.

•Kris Kuipers has produced a CD of classical music: guitarist Anthony Glise plays "The Partitas of Giuseppi Antonio Brescianello ca. 1690 - 1757", on the Dorian Discovery label, #DIS-80127. Might be something to check out if your bootleg concert tape of the Skeffingtones isn't impressing your dates.



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Contributions of art can consist of cartoons, fillos, photos, etc. We prefer good black photocopies to original art.

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